FARMERS' BELIEFS AND PERCEPTIONS OF CLIMATIC VARIABILITY AND CHANGE: IMPLICATIONS ON ADAPTATION DECISIONS

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ABSTRACT

Recent studies have shown that farmers' adaptive responses are shaped by their perceptions about variability and change in local climatic parameters. There is substantial evidence to suggest that farmers' perceptions on local climate are based on shared beliefs transmitted through local knowledge systems. This study examines the shared beliefs and perceptions held by village tank farmers in dry zone, Sri Lanka.

Study was guided by a conceptual framework that connects farmers' beliefs with dual type of rainfall expectations identified as normal rainfall expectations (NREs) and seasonal rainfall expectations (SREs). NREs are farmers' beliefs about local climatic variability which are updated seasonally to derive SREs with the aid of local climatic indicators, another set of beliefs. The study was carried out in nine villages under three cascade systems in Anuradhapura district. Primary data was gathered through conducting a household survey and focus group discussions. Descriptive statistical methods and qualitative tools were used to analyse the data. NREs were elicited by analysing farmers' monthly rainfall expectations.

Results of the study outline the NREs of farmers based on their monthly expectations about rainfall amount, number of rainy days and level of rainfall fluctuation. Focus group discussions helped to identify farmers' beliefs that underline NREs. Farmers have beliefs about seasonal as well as intra-seasonal variability of rainfall. Beliefs about seasonality are founded on two farmer-defined seasons, Maha and Yala. Intra-seasonal variability of local rainfall is captured by beliefs about a sequence of rainfall events connected to temporal milestones. Beliefs about seasonal and intra-seasonal variability constitute a local model of rainfall variability that provides a template for updating with local climatic indicators. Results also describe the nature of local climatic indicators reported in discussions with farmers.

INTRODUCTION

Farmers in village tank systems in the dry zone of Sri Lanka depend on local rainfall for their livelihood. In the dry zone, conditions of water stress usually prevail throughout the year except for relatively short rainy period (Alles, 1971; Tennakoon, 1986; Panabokke and Punyawardena, 2010). Distribution of rainfall in many localities shows high annual variation, resulting in significant fluctuations (Yoshino *et al.*, 1983; Yoshino and Suppiah, 1983). Fluctuation of rainfall sometimes leads to extreme events giving rise to widespread livelihood damages. Consequently, village tank farmers carry out their livelihood activities under persistent risk of rainfall fluctuations.

Village tanks, a type of community owned rainwater-harvesting facilities; enhance their efforts to a certain extent by helping to store the surplus from the short rainy season to be used in the lengthy dry spell that follows. They collect and store water from direct rainfall and runoff flow of local precipitation. It has been estimated that over 18,000 village tanks are scattered in the dry zone areas of the country (Ratnatunge, 1979; Somasiri, 1980). In addition to village tanks, agro-wells-a recent innovation-enable a section of farmers to tap the groundwater storage based on shallow regolith aquifers confined to limited areas in the local landscape (Panabokke and Perera, 2005; Panabokke, 2007).

Despite the support from these facilities, basic conditions of rainfall risk faced by farmers remain unchanged. Village tanks as well as agro-wells are dependent on local rainfall and an adverse fluctuation in rainfall, even in a single year, can lead to conditions that could affect the livelihood security of farmers in detrimental manner. Unforeseen effects of global climate change have the potential to complicate the situation further. Recent studies have indicated a significant decline in mean annual rainfall in many areas of the dry zone over the past 140 years (Costa, 2008; Eriyagama *et al.,* 2010). It has been projected that this decline may lead to increase in irrigation water requirement in paddy by 13-23% by 2050. Several dry zone districts including *Anuradhapura,* which has the highest area under village tanks, were identified as vulnerability hotspots by a recent study conducted by the International Water Management Institute (IWMI) (Eriyagama *et al.,* 2010). In addition, studies suggest that intensity and frequency of extreme climate events have increased during the recent period (Eriyagama *et al.,* 2010; Imbulana *et al.,* 2006; Ratnayake and Herath, 2005). Overall, evidence on climate change indicates that village tank farmers are likely to face more severe conditions of water stress in the future.

Adaptation and farmers' beliefs

Adaptation has been the key strategy that helped farmers all over the world to face the climatic uncertainty and village tank farmers are not an exception to this. Adaptation is a continuous process of adjustment that helps to moderate, cope with or take advantage of the impacts of climatic variability and change (IPCC, 2001 and 2007). Adaptation decisions are essentially risky choices that can give rise to diverse outcomes subject to variable events of climate (rainfall). Achieving the desired outcomes of adaptation depends on making adjustments to match with climate events to come. When making adaptation decisions, farmers have to make expectations about rainfall that ultimately determines the final outcomes of their choices. Therefore, farmers' rainfall (climate) expectations play a major role in their decisions on adaptation (Hansen *et al.,* 2004; Marx *et al.,* 2007; Weber, 1997).

There is significant evidence that indicates farmers' rainfall expectations are influenced by 'shared beliefs' about local rainfall (Roncoli *et al.,* 2002; Orlove *et al.,* 2007; Slegers, 2008). Farmers appear to place their trust upon locally shared beliefs formed over long-term collective memory as a guide for making rainfall expectations. Usually, such beliefs encompass a familiarity with local weather patterns and set of local signs that provide clues about oncoming climate (rainfall) events (Orlove *et al.,* 2007; Slegers, 2008). Those signs appear in local environment and can be called as local climate indicators. Farmers get access to shared beliefs through a social process of knowledge transmission (Orlove *et al.,* 2007; Roncoli *et al.,* 2002).

There is evidence to suggest that such beliefs on local climate exist among village tank farmers also (Punyawardena, 2009; Tennakoon, 1986). An unmistakable evidence for such beliefs is local agricultural calendar based on two farmer-defined seasons known as *Maha* and *Yala*. Punyawardena (2009) observed that certain local beliefs correspond closely with the general pattern of 'climatic year' in dry zone indicated by systematic analysis of weather data. Tennakoon (1986) provided an account on certain local beliefs held by village tank farmers on the conditions of droughts and dry spells. Tennakoon (1986) further documented local indicators used by farmers to predict a 'drought in offing'. Important clues about the existence of shared beliefs in village tank systems are provided also by collective decisions on practices such as '*bethma*' (Aheeyar, 2001; Panabokke *et al.,* 2002; de Jong, 1989). Such community-based adaptation practices would not have been possible unless facilitated by shared beliefs to form common expectations about rainfall.

The objective of this study was to examine village tank farmers' beliefs on local rainfall to understand how they influence farmers' adaptation decisions. It was guided by a conceptual framework that connects farmers' beliefs to local rainfall expectations. Empirical findings of the study were based on primary data collected in several village tank sites in *Anuradhapura* district.

Conceptual framework

The study was guided by the conceptual framework presented in this section. This framework presents a conceptual model on farmers' rainfall expectations. According to this model farmers' decisions on adaptation are based on dual types of rainfall expectations that can be identified as:

- Normal rainfall expectations (NREs) and,
- Seasonal rainfall expectations (SREs)

Normal rainfall expectations (NREs)

Normal rainfall expectations (NREs) refer to farmers' shared beliefs about local rainfall distribution, a local model of rainfall variability. NREs capture continuous variability of rainfall in an annual cycle consisted of farmer defined seasons and intra-seasonal variability within them. It provides a standard rule regarding a 'normal' rainfall year thereby serving as a template for making expectations on rainfall at a given period of time of the year. It also offers a reference for detecting and observing changes from the normal pattern. A simplified representation of the farmers' model is given in Table 1, which is characterized by joint expectations about amount (magnitude) and fluctuations (variability) of rainfall. It does not cover intra seasonal variability.

Seasonal rainfall expectations (SREs)

Farmers have to form seasonal rainfall expectations (SREa) in every season for making their adaptation decisions and they use NREs as a template to derive SREs. SREs are conditional expectations based on the prior beliefs (NREs). Farmers update NREs with the aid of local climate indicators. Local climate indicators are signs of rainfall observed in the local environment by farmers. Unlike NRE, which are shared beliefs, SRE are individual expectations. Fig. 1 provides a schematic representation of this process.

This conceptual framework on belief-based rainfall expectations has important implications towards understanding farmers' decisions on

Table 1. A template of NREs

		Rainfall amount					
		Season 1			Season 2		
		Low	Medium	High	Low	Medium	High
Rainfall variability	Low						
	Medium						
	High						

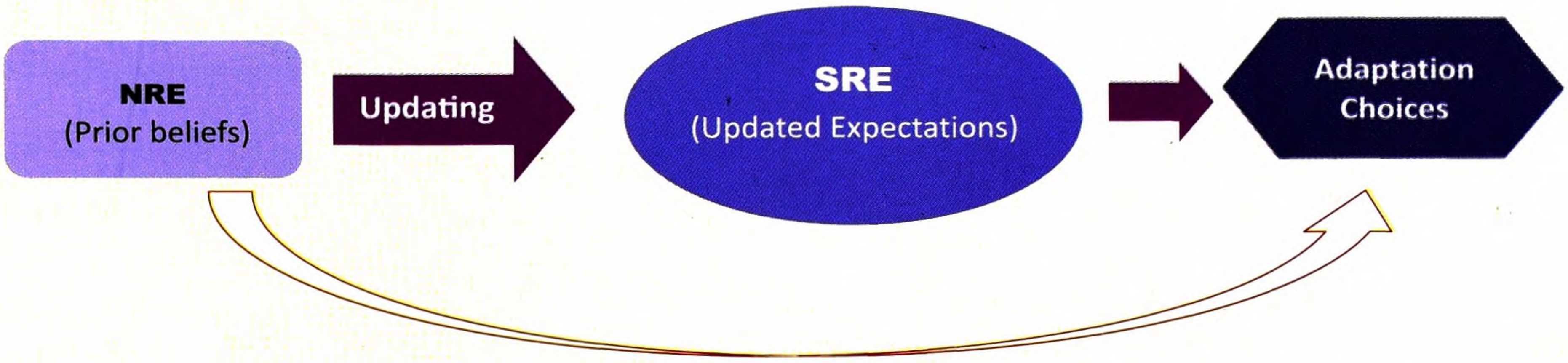

Fig. 1. Schematic representation of updating of rainfall expectations

adaptation responses. Adaptation refers to adjustments in behavior of farmers in response to changes in conditions resulting from actual or expected variability or change in climate in order to cope with harmful impacts or to take advantage of opportunities (IPCC, 2007).

According to that two fundamental conditions that motivate farmers to take adaptive actions are recognition of: (a) changes in conditions and, (b) likelihood of impacts (harmful impacts or opportunities) associated with those changes. Farmers use either NREs or SREs when making choices among alternative adjustments depending on the nature of adaptation choices involved (Fig. 1).

NREs provide the benchmark against which the changes in conditions have to be recognized. NREs as a reference can accommodate a range of short-term fluctuations by updating with local indicators to be captured through seasonal rainfall expectations (SREs). Therefore, short-run adaptation decisions of farmers are motivated by changes indicated for NREs by local indicators. NREs being a part of farmers' long-held beliefs can be considered as relatively stable over short- to medium-term. In the long run, circumstances that lead to modification of beliefs (NRE) could arise. Global climate change represents such a circumstance. Climate change is usually defined as the long-term shifts in the mean state and variability of climatic parameters (Smit *et al.*, 2000). Since NREs can be considered as a psychological (subjective) parallel to the objective phenomenon of mean state and variability of rainfall, they have a major role to play in farmers' detection and perception of global climate change.

METHODOLOGY

Study site and data sources

The study was carried out in nine tank villages belonged to three cascades systems in *Anuradhapura* district, namely: *Mahakanumulla, Tirappane* and *Periyakulama* cascades. The list of selected tanks in three cascades is given in the Table 2.

Major sources of primary data a household survey in selected villages and three focus group discussions (FGD) conducted with farmers from each cascade. Household survey was conducted using a sample of 181 farm households. It was carried out using a structured interview schedule and heads of households were interviewed at their premises. In the survey, particular attention was directed to elicit farmers' NREs by asking farmers' expectations regarding following three parameters.

- *Amount of rainfall:* Farmers' expectations about rainfall amount for each calendar month of the year were elicited using a scale of 1-5 on increasing order of rainfall
- *Number of rainy days per month:* Farmers' expectations on number of rainy days per each month

Expected level of fluctuation

Farmers' chose whether expected fluctuation of rainfall for a given month was high or low

FGD is a participatory method of data collection. Three focus group discussions (FGDs) were conducted with the participation of farmer groups of the size of 10-12 using a semi-structured focus

Table 2. List of primary data gathering sites (villages)

Cascade system	Village tanks
Tirappane	• *Tirappane* tank • *Meegassegama* tank • *Bulankulama/ Wendarankulama* tanks
Mahakanumulla	• *Mahakanumulla* tank • *Walagambahuwa* tank • *Paindikulama* tank
Periyakulama	• *Periyakulama* tank • *Mawathawewa* tank • *Padiketuwewa* tank

guide. Discussion groups were selected to represent different levels of experience/ knowledge ranging from younger generation farmers with few years of experience to mature age farmers with several years of experience. In the discussions, following aspects relating to farmers' adaptation decisions were discussed.

- Local beliefs about rainfall variability
- Local climate indicators and farmers' use of them
- Farmers' past experience on adaptation
- Farmers' perceptions of long-term changes in rainfall

Data analysis

Two major types of descriptive analytical tools were used to analyse the household data from the survey, namely; (a) estimation of descriptive statistics and, (b) cross tabulation. Selected variables of cross-sectional data set was analysed by estimation of key statistics depending on the nature of variables as follows. Key variables covered in the survey were number of rainy days, expected amount of rainfall by month (scale of 1-5) and level of rainfall fluctuation Cross-tabulations were used to summarize data.

Information collected in FGDs was qualitative in nature. Examples are locally shared beliefs on rainfall and local climate indicators. They required lengthy discussions for exploring and collective brainstorming. Therefore, qualitative methods of analysis were used to analyze the data from FGDs. This has mainly been achieved through organization of information into tables and matrices.

RESULTS AND DISCUSSION

Profile of sample households

The sample of 181 included 86.7% male respondents and 13.3% female respondents. Average family size of the sample was 3.9. Age of the respondents varied in the range of 22-72 years with the average of 50 years. Age composition of the respondents included households headed by young respondents (< 35 years), households headed by middle-aged respondents (36-55 years) and households with elderly heads (> 55 years). The sample had 14%, 53% and 33% households under young, middle age and elderly categories respectively. A majority (76.2%) was educated beyond the primary education level and 53% had finished formal education after G.C.E (Ordinary Level) examination. One fourth of the sample had completed secondary education up to G.C.E (Advanced Level) examination. Two respondents (1.2%) had tertiary level qualifications. Literacy rate of the sample was 100% given that all respondents had formal education up to a certain level.

A majority of respondents (77.9%) were full time farmers. The rest (22.1%) were engaged in some other occupation while also involving in farming on part-time basis. Farming experience of respondents varied in the range of 1-55 years.

Normal rainfall expectations (NREs)

Table 3 presents farmers' normal expectations on monthly rainfall amounts, average number of rainy days per month and level of rainfall fluctuation in each month. Nine respondents failed to offer satisfactory responses and percentages given in the table refers to total number of valid responses (172). Over 95% respondents ranked their rainfall expectations for November and December at the level 4 or above. This is followed by January and April at which over 77% farmers ranked their expectations at the level 3 or above. The lowest rainfall expectations were reported for June, July and August, which have been ranked at level 1 by around 95% respondents. A majority of farmers expected February (75%) and May (72%) rainfall at the level 1. More scattered responses have been reported for months of March, September and October-October having roughly equal number of respondents at the levels of 2, 3 and 4 (altogether 81.4%) with a significant number (16.3%) at the level 5 as well.

Table 3 also present average number of rainy days farmers' expected in respective months. Their expectations about number of rainy days seem to be corresponding with expectations about rainfall amount for each month. Accordingly, months with

Table 3. Famers' normal rainfall expectations about amount of rainfall by month

Month	Amount of rainfall: 1-5 scale (% farmers)					Average no. rainy days	Level of fluctuations (% farmers)	
	1	2	3	4	5		Low	High
January	0.6	22.1	69.2	7.6	0.6	10.13	16.9	83.1
February	75.0	20.9	2.9	1.2	-	1.05	90.1	9.9
March	36.0	41.9	9.3	9.9	2.9	2.49	68.3	31.7
April	1.7	20.9	50.0	20.3	7.0	7.48	65.5	34.5
May	72.7	23.8	3.5	-	-	1.18	93.7	6.3
June	94.8	5.2	-	-	-	0.18	94.4	5.6
July	98.8	0.6	0.6	-	-	0.09	99.3	0.7
August	97.7	1.7	0.6	-	-	0.13	95.8	4.2
September	56.4	27.9	8.7	4.7	2.3	2.06	78.9	21.1
October	2.3	23.8	29.1	28.5	16.3	7.91	70.4	29.6
November	-	0.6	2.9	10.5	86.0	24.27	85.2	14.8
December	-	0.6	1.7	13.4	84.3	25.32	85.2	14.8

low expected rainfall amount, namely, June, July, August, February, May, September and March were expected to have low number of rainy days (0-5) by over 90% of respondents. On the other hand, November and December months with high expectations about rainfall amount were expected to have high number of rainy days (>20) by over 75% respondents. For January, April and October months with middle level expectations about rainfall expected number of rainy days varied in the range if 7-10 days.

As far as farmers' perceptions about rainfall fluctuation in respective months are concerned, over 90% assessed that level of fluctuation of rainfall in February, May, June, July and August as 'low rainfall months' in terms of expected rainfall amount and number of rainy days is generally low. Similarly, over 85% assessed fluctuation in November and December 'high rainfall months' also as low. This implies high confidence on farmers' assessment for months with the lowest and highest expectations of rainfall. Number of respondents that expected high level of fluctuation increased progressively for September (21.1%), October (29.6%), March (31.7%), April (34.5%) and January (83.1%). Overall, a majority of farmers expected that fluctuation of rainfall to be low in general except for January.

NREs and farmers' beliefs

Numbers given in the Table 3 provided a numerical outline about farmers' NREs. However, interactions with in FGDs suggested that farmers usually hold their beliefs in vivid mental images of events connected to various temporal milestones. Discussions suggest that farmers have beliefs covering seasonal as well as intra-seasonal variability of rainfall. Farmers' beliefs about seasonality of rainfall are encoded in the local agricultural calendar with two farmer-defined cultivation seasons, *Maha* and *Yala*. *Maha* is a period of high rainfall expectations extended from mid-September to mid-March. *Yala* season is relatively a dry period with a short rainy period in March-April. Belief on two seasons helps farmers to organize their activities with rainfall expectations on a seasonal basis.

FGDs also helped to identify farmers' beliefs on rainfall events that constitute intra-seasonal distribution of rainfall. They are summarized in the Table 4.

These beliefs carry information on two major dimensions of events-usual time and intensity/nature of events that help to form expectations about intra-seasonal variability of rainfall.

Table 4. Beliefs associated with intra-seasonal distribution of rainfall

Month	Local Name for Rainfall Event	Time of Rainfall Event	Nature of Rainfall Event
January (*Duruthu*)	*Duruthu wehihella (werahella)*	Throughout the month	Low intense continuous rains
February (*Navam*)		Early period of month	Scarce occasional rains
March (*Medin*)	*El eta pelawena wehi, Tala wehi*	Late period of month	Evening rains with thunder and lightening
April (*Bak*)	*Bak maha wehi, Tala wehi,*	Rainy period can shift (early, mid or late)	Evening rains with thunder and lightening
May (*Wesak*)	*Mee mal mandarama, Wel mal mandarama*		Dark cloudy sky
June (*Poson*)	*Maluwa hedena wehi*	After full moon	Scarce occasional rains
July (*Esala*)			Scarce occasional rains
August (*Nikini*)	*Nikini palu wehi*	After full moon	Scarce occasional rains
September (*Binara*)	*Binara kaluwa Nikini palu wehi, Wehi tuna*	A pre-rain period Rains after 20 September or early October or after full moon	A few intensive rains
October (*Wap*)	*Wap idella Akwessa (Mul wehi)*	Dry spell in the early month Rains around or after15 October	Scattered, intensive rains
November (*Il*)	*Il maha wehi,*	Rains throughout the month	Continuous, intensive rains
December (*Unduwap*)	*Undu raluwa* *Nattal kunatu*	Rains throughout the month. Rains during the early to mid-period (around 15 days) Stormy rains in the late month (around 20–30 December)	Continuous, intensive rains

Time of events

Events were connected to months in local lunar calendar (*e.g. Duruthu wehihella, Bak maha wehi, Il maha wehi, Nikini palu wehi, Undu raluwa*) or specific religious/social events in the area (*e.g. Maluwa hedena wehi, Nattal kunatu*).

Intensity/nature of events

Farmers also have a local terminology to describe the nature/intensity of rainfall events (*e.g. Wehihella, Mandarama, Kaluwa, Idella*).

Farmers' beliefs on cultivation seasons and intra-seasonal events described here can be considered as a local model of rainfall variability. Through this model farmers attempt to capture the complex pattern of local rainfall variability and form rainfall expectations.

Farmers' belief-based model on seasonal and intra-seasonal variability basically represents normal rainfall expectations (NREs) that deal with deterministic component of rainfall variability. Even the subtle aspects covered by farmers' model cannot take stochastic fluctuations of rainfall into

Table 5. Summary of the local climate indicators

Signs, indicators & predictors	Nature of observations	Time lag of forecast	Remarks
Beliefs about rainfall events connected to milestones	- Occurrence of expected events in relation to milestones (early, usual, late or non-occurrence)	Serve as predictors of immediate events as well as general projections about season to come	Appears to be the most important indicators for the seasonal updating of rainfall.
Observations on wind, sky and clouds	- Direction, speed and nature of wind movement - Specific cloud formations, cloudiness and colour of the sky - Occurrence of fog, mirage etc.	Serve as short-term predictors of rainfall events to come. Time lag may be around 1-10 days	Commonly observed indicators along with the predictions based on events connected to milestones.
Local hydrological phenomena	- Water level, spread area and spilling of tanks - Water level of wells	General indicators of rainfall potential of the unfolding season	Essential observations taken into consideration when decisions on joint adaptation are taken. Farmers have identified 'indicator' tanks and wells.
Thermal changes in the environment	- Sudden changes in temperature in notable manner (warm or cold) especially in morning and night times	Short-term predictors of weather events with a few days' time lag	There is a natural tendency among farmers to take such changes as signs of forthcoming weather events.
Cosmological phenomena	- Visibility and brightness of stars - Width and intensity of aura of moon	Short-term predictors of weather events with a few days' time lag	Generally held beliefs that can strengthen the confidence on other predictors when they coincide with them.
Resurgence of indicator species	- Sudden rise in insect populations (mosquitoes, fire flies) - Appearance of certain species of animals (e.g., birds)	Short-term predictors of rainfall events with a few days' time lag	Generally held beliefs that can strengthen the confidence on other predictors when they coincide with them.
Specific observations on animal behaviour and local fauna	- Nesting behaviour of certain bird species - Relative abundance of flowering and fruiting of local tree species	Predictors with relatively longer time lags that may vary from few weeks to few months; usually of rainfall conditions of forthcoming season	Respected as local wisdom yet with limited current use. Limited experience and knowledge in young farmers. Changes in the local environment (e.g., clearing of forests) have made them obscure.

account in adequate manner. In this connection, farmers are assisted by another set of beliefs local climate indicators. They help farmers to update NREs so that to derive SREs. Table 5 provides a summary of information gathered on local climatic indicators in FGDs.

Predictions based on local indicators have different time lags that may extend from few hours to few months. Discussions revealed that indicators based on wind/sky/clouds, local hydrological phenomena and thermal changes in the environment are still widely used by farmers to update their rainfall expectations. Comparatively, cosmological phenomena, indicator species and observations on animal/plant behaviour are less frequently observed by farmers now. Less knowledge about and changed attitudes of younger generation farmers is one reason for decline of the usage of certain signs/indicators. Moreover, changes taken place in local environment has made it difficult to observe certain phenomena. For instance, certain observations on animal/plant behaviour have become rare due to clearance of local forest patches. Therefore, such phenomena can no longer be relied upon to make regular decisions.

Discussions highlighted few important points about local indicators. Firstly, signs/indicators are closely connected to beliefs on rainfall events (given in Table 4). Accordingly, early, usual or delayed occurrence (or non-occurrence) of events with respect to expected milestones provides a basic rule for farmers to update their expectations. Secondly, when several indicators support farmers' expectations, they gain more confidence on the likelihood of an event. On the other hand, when indicators contradict, farmers would be more cautious in their decisions.

CONCLUSIONS AND POLICY IMPLICATIONS

The results of this study support the conclusion that farmers' shared beliefs on local rainfall guide their adaptation decisions. Results also suggest that farmers' beliefs provide a basis for making rainfall expectations about seasonal and intra-seasonal events of rainfall thereby enabling to make risky choices of adaptation. Farmers have to update normal expectations to cope with fluctuations and observations on local climate indicators help to update rainfall expectations accordingly. In every season, farmers adjust operational arrangements of activities to a certain extent in response to stochastic fluctuations of rainfall. They can be considered as fine-tuning adjustments.

The foremost policy implication of the study is highlighting the importance of farmers' beliefs on their adaptation choices. Findings are directly relevant in the case of ongoing debate over the usefulness of climate information products such as long-term climate projections, seasonal precipitation forecasts (SPF) and short-term weather forecasts (Gadgil *et al.,* 2002; Gine *et al.,,* 2009; Hansen *et al.,* 2011; Ingram *et al.,* 2002; Luseno *et al.,* 2003; Meza *et al.,* 2008; Roncoli, 2006; Stone and Meinke, 2006; Ziervogel, 2004). According to some scholars climate information products can be competing with farmers' beliefs (Lybbert *et al.,* 2007). Findings of this study support this idea. For instance, NREs can compete with SPF and local climate indicators can substitute short-term weather forecasts at least partially. This implies that current information products are knowingly or unknowingly aimed at substituting farmers' beliefs. Given the strong connection of farmers' beliefs to their adaptation decisions, it is logical to expect that assessing the influence of beliefs would help to improve the effectiveness of such interventions. The findings of the study strongly emphasize the importance of taking farmers' beliefs into consideration in designing, producing and communicating climate information products and interventions based on them.

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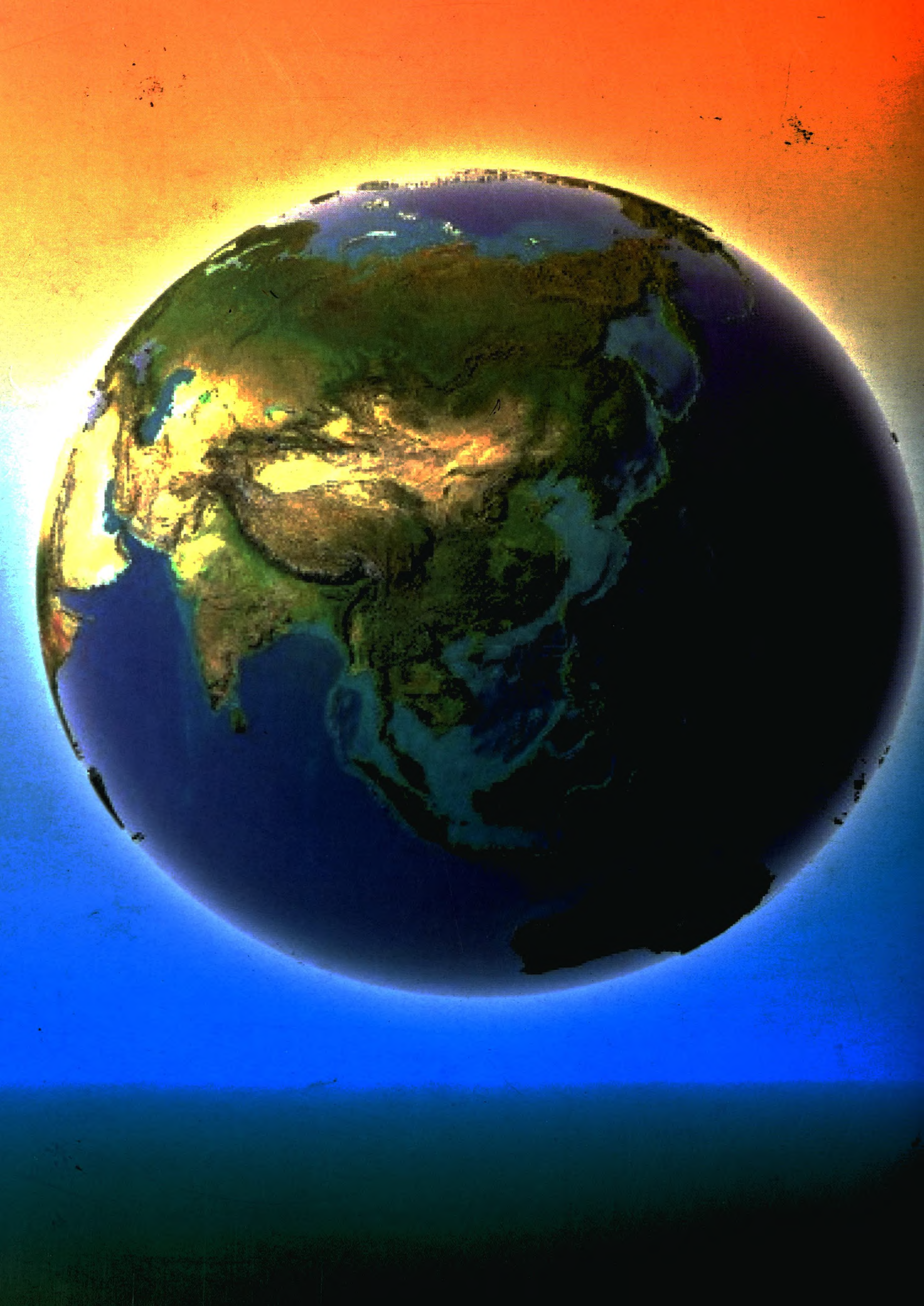

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